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The Production Of A Green Surface Color On Texture Face Brick

THE PRODUCTION OF A GREEN SURFACE COLOR ON TEXTURE FACE BRICK

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THESIS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Reinhard August John Steinmayer

ENTITLED The Production of a Green Surface Color on Texture Face Brick

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

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THE PRODUCTION OF GREEN TEXTURE.

The manufacture of rough texture brick has brought with it the problem of producing various shades and surface effects, among which is the green color characteristic of old buildings and castles of Europe.

There are several methods of producing the desired color which may be considered, namely:

1. Incorporate an oxide with the clay body.
2. Burning the ware in the presence of volatile salts. [1]
3. Application of a matte glaze by dipping or spraying. [2]

INCORPORATING AN OXIDE WITH CLAY BODY.

It is practical to incorporate certain coloring materials, such as, ferric oxide, and manganese dioxide in a buff burning body, for the purpose of producing brown shades or speckled effects, but the cost of copper or chromium oxide would make the production of a green shade by this method prohibited. Also it would be necessary to have a white or light burning body in order to produce desirable shades.

BURNING THE WARE IN THE PRESENCE OF VOLATILE SALTS.

The process would be similar to salt glazing, that is, volatile salts [3] such as sodium chromate, potassium dichromate, or chronium chloride, would be thrown in the fire boxes when

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1. Transaction A.C.S. Vol. 5, p 115
2. Transaction A.C.S. Vol. 14, p. 671
3. The Effect of Heat upon Clay. (Bleininger)

the kiln has reached.the maturing temperature. Or the salt may be thrown into the kiln thru the crown holes, and after voltalizing is carried thru the kiln. The chromium unites with the clay and silica of the body producing a green colored glaze on the surface of the ware. This method is used commercially and with considerable success by some clay products companies. It was not attempted in this investigation because the salts would be deposited on the wall of the laboratory kiln and its effects would be noticeable on the wa re, burned in the kiln, for considerable time afterward.

THE APPLICATION OF A MATTE GLAZE.

The present investigation deals with the last method namely that of applying a glaze to theware. Slips [1] and glazes may be applied by dipping, spraying, and by automatic veneering dies. Hand dipping is the most expensive. The automatic veneering devise would not be suitable in the production of rough texture brick because it would produce a smooth surface. Spraying seems to be the best method and can be applied to the clay column as it comes from the auger machine, or after the brick have been cut and transferred to pallets.

TYPE OF CLAY-BODY

A shalefrom La Salle, Illinois was used as the clay body

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1. Transactions A.C.S. Vol. 16. p 144

upon which the glazes were applied. This shale has a large drying shrinkage and it is a difficult problem to apply a glaze which will not flake off during the drying of the ware. The shale has a short vitrification range having a porosity of from 6 - 8% at cone 03 and is vitrified when a temperature of cone 2 is reached. Experience has proved that cone 03 is the proper maturing temperature, hence this investigation was designed to produce a green matte glaze maturing at cone 03.

EXPERIMENTAL WORK.

Purdy[1] developed a matte glaze having the formula:-

$$\left.\begin{matrix} .575\ PbO \\ .200\ CaO \\ .225\ K_2O \end{matrix}\right\} .35\ Al_2O_3 \left\{ 1.6\ SiO_2 \right.$$

which matures at cone 05 - 5 and which he states will not scum. The above glaze was a compounded and applied to the trials in the leather hard conditions. They were placed in saggers and fired in a gas fired kiln at the rate of 50° C per hour until cone 03 went down. The kiln was allowed to cool for twenty four hours and the trials were drawn and examined. It was found that the above glaze became glossy when applied to the shale body.

SERIES A.

LEAD - ALKALI - ZINC - . MATTE GLAZES.

This series, table 1, was developed in the glaze course at the University of Illinois and gave excellent results on white biscuited tile. It was tried on this shale but all trials came out glossy. This is probably due to the fact that the glaze

1. Trans. Amer. Cer. Soc., Vol. 14.

absorbed silica from the body.

SERIES B.

LEAD - ALKALI - ZINC - MATTE GLAZES.

The four corner glazes of this series were weighed out and mixed by grinding wet in a ball mill for two hours, screened and the remaining glazes of the series made up by blending those four corner glazes. The trial pieces were made up in the form of small rough texture brick. The glazes were applied to the trials by dipping, when the brick were both in the leather hard and dry states. A one percent solution of glue was used to keep the glaze from flaking off. The trials were set in a coal fired down draft test kiln in saggers and burned to 1060° C, the temperature being raised at the rate of 25° C per hour. The fires were then drawn and the kiln was allowed to cool for twenty four hours.

RESULTS OF SERIES B

The best matte glazes were obtained when the molecular ratio did not exceed 1:5 and with a alumina content between .24 and .3 equivalent. As the molecular ratio exceeded 1:5 the glazes became more glossy until finally when the ratio reached 1:6 we got distinct glossy glazes.

Glazes A_1; B_2; B_3; B_4; C_3; C4; and D_4 were all good matte glazes.

The best glaze of the above was C_4

Glaze C_4

$$\left.\begin{array}{ll} .665 & PbO \\ .067 & ZnO \\ .10 & CuO \\ .6 & K_2O \end{array}\right\} .265\ Al_2O_3 \left\{ 1.285\ SiO_2 \right.$$

Glazes A_2; B_1; and C_2 showed a semi-matte structure.

The remaining Glazes in the series were distinctly Glossy.

SERIES C .

LEAD - ALKALI - LIME - MATTE GLAZES.

A series of Alkali-lime glazes was next tried upon the shale body. The RO is constant thru out the entird series. The Alumina va ried from .2 to .4 equivalents and the silica from from 1.0 to 2.0 equivalents. The four corner glazes of the series were compounded and blended to make the remaining glazes of the series. The glazes were applied to trials, in the form of small rough texture brick which were both in the dry and leather hard conditions. A one per cent solution of glue was added as in the fore going series to keep the glaze from flaking off upon d rying. The trial were fired in the coal fired test kiln at the rate of 25° C per hour to 1060° and the kiln was allowed to cool for 24 hours.

RESULTS OF SERIES C.

The best mattes were obtained with a molecular ratio of 1:3 to 1:5, which is nearer the lower limit given by Bleininger in his

matte glaze classification, and with a alumina content between .3 and .35 equivalents. When the molecular ratio was between 1:5 and 1:8 the glazes became simi-matte with a tendency to become more glossy as the mol e cular ratio increased. With a molecular ratio of 1:5 to 1:10 and when the alumina content did not exceed .3 equivalent all glazes became distinctly glossy. With an increase of alumina to .35 equivalents or more all glazes were immature.

Glazes B_1; C_1; C_2; D_1;D_2; D_3 were all good matte glazes.

The best glaze of the above was D_2.

$$\left.\begin{array}{l} .5\ PbO \\ .15\ K_2O \\ .25\ CaO \\ .10\ CuO \end{array}\right\} \quad .35\ Al_2O_3 \left\{ \quad 1.25\ SiO_2 \right.$$

Glazes B_4; B_5; C_4; C_5 showed a semi-matte structure which gave a very pleasing glaze.

All the remaining glazes in the series were distinctly glossy.

CONCLUSIONS.

Although we may develope a green matte glaze, maturing at the same temperature as the clay body, giving excellent results upon a white biscuited tile does not prove that the glaze would give good results when applied on an unburned shale.

Every type of shale presents a different problem. It is self evident that a glaze which gives good results upon a siliceous shale would probably give poor results upon one high in alumina.

A very pleasing effect is produced by applying an uneven coating of glaze upon our texture brick. The brick upon being burned show an odd mottled effect of greenand red, or what ever color our

clay body may burn.

The relative merits of the Lead-Alkali-Zinc glazes and the Lead-Alkali-Lime glaze is not noticeable, but the lime would make a much cheaper type of glaze and therefore would be the more desirable of the two to use.

Table 1 Series A Cone 03

Matt Glazes

	PbO	K_2O	ZnO	CuO	Al_2O_3	SiO_2	O.R	Molecular Ratio
A 1	.60	·15	·15	·10	.30	1·35	1.42	1:4·5
A 2	.60	·15	·15	·10	·30	1.73	1.82	1:5·7
A 3	·60	15	·15	10	·30	2.11	2.22	1:7
A 4	·60	·15	·15	·10	·30	2:5	1.92	1:8.3
B 1	.566	·167	·167	·10	.30	1.73	1.63	1:57
B 2	·566	·167	·167	·10	·30	1.86	1.7	1:62
B 3	·566	·167	·167	·10	·30	1.98	1.75	1:6·6
B 4	·566	·167	·167	·10	·30	2·11	1.79	1:7
C 1	·533	·184	·184	·10	·30	2·11	1.79	1:7
C 2	·533	·184	·184	·10	·30	1.98	1.75	1:6·6
C 3	·533	·184	·184	·10	·30	1.86	1:7	1:62
C 4	·533	·184	·184	·10	·30	1·73	1·63	1·5·7
D 1	·50	·20	·20	·10	·30	2·5	1·92	1:83
D 2	·50	·20	·20	·10	·30	2.11	2·22	1:7
D 3	·50	·20	·20	·10	·30	1·73	1·82	1:57
D 4	·50	·20	.20	·10	·30	1.35	1·42	1:4·5

Plate 1

Series A

Cone 03

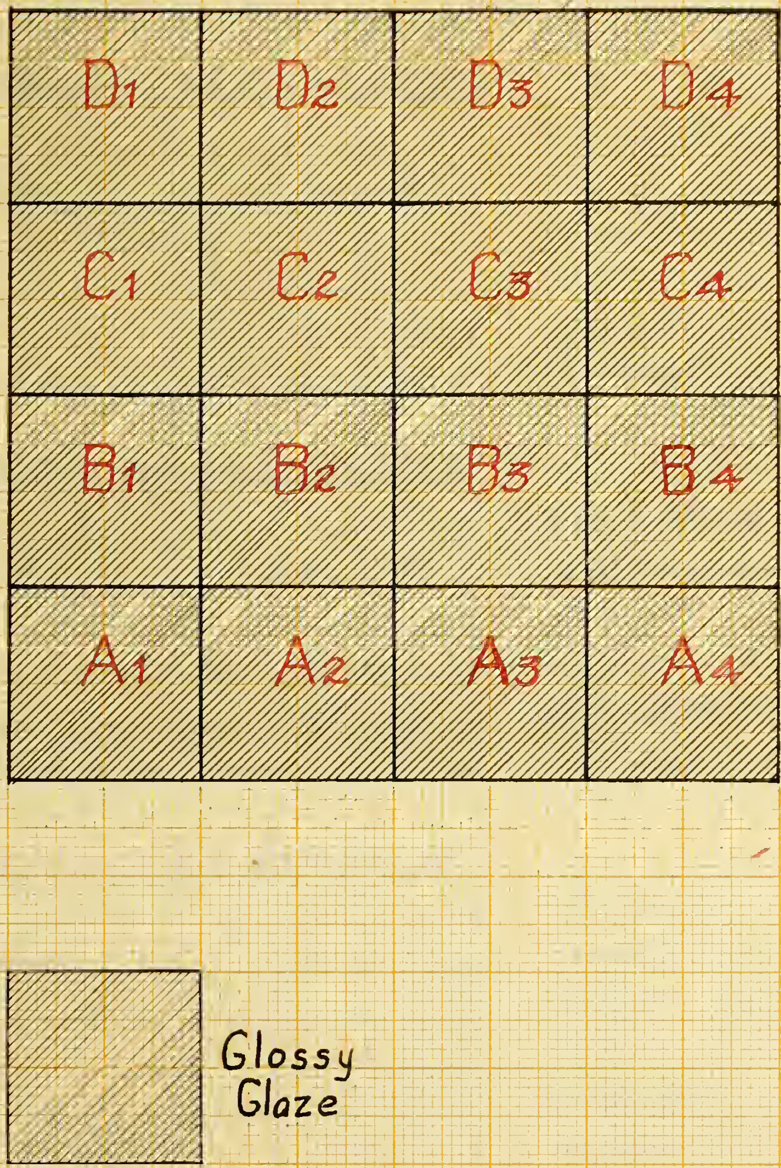

Table 1a Series A Cone 03

Batch Weight Calculations of the Four Corner Glazes

A1	·6PbO	·15K₂O	·15ZnO	·10CuO	·3Al₂O₃	1·35SiO₂
	·60					
		·15			·15	·90
			·15			
				·10		
					15	·30
						15

·6 Red Lead = ·6 X 228 = 136·8
·15 K. Spar = ·15 X 556 = 83·5
·15 ZnO = ·15 X 81 = 12·15
·10 CuO = ·10 X 80 = 8
·15 Tenn B.C = ·15 X 258 = 38·7
15 Flint = ·15 X 60 = 9·0
288·15

A4	·6PbO	·15K₂O	·15ZnO	·10CuO	3Al₂O₃	2·5SiO₂
	·60					
		·15			·15	·90
			·15			
				·10		
					·15	30
						1·3

·6 Red Lead = ·6 X 228 = 136·8
·15 K. Spar = ·15 X 556 = 83·5
·15 ZnO = ·15 X 81 = 12·15
·10 CuO = ·10 X 80 = 8
15 Tenn B.C = ·15 X 258 = 38·7
1·3 Flint = 1·3 X 60 = 78
357 15

D1	·5PbO	·2K₂O	·2ZnO	·10CuO	3Al₂O₃	2·5SiO₂
	·50					
		·20			·20	1·2
			·20			
				·10	·10	·2
						1·1

·5 Red Lead = ·5 X 228 = 114
·2 K Spar = ·2 X 556 = 183·5
·2 ZnO = ·2 X 81 = 16·2
·10 CuO = ·10 X 80 = 8
·10 Tenn B.C = ·10 X 258 = 25·8
1·1 Flint = 1·1 X 60 = 66
343·0

D4	·5PbO	·2K₂O	·2ZnO	·10CuO	·3Al₂O₃	1·35SiO₂
	·5					
		·2			·2	1·2
			2			
				·10		
					·10	

·5 Red Lead = ·5 X 228 = 114
·2 K Spar = ·2 X 556 = 183·5
·2 ZnO = ·2 X 81 = 16·2
·10 CuO = ·1 X 80 = 8
·10 Tenn B.C = ·1 X 258 = 25·8
277·0

Table 2 Series B Cone 03

Matte Glazes								
Lead-Alkali-Zinc								
	PbO	K_2O	ZnO	CuO	Al_2O_3	SiO_2	O.R.	Molecular Ratio
A_1	·80	·10	0	·10	·30	1·33	1·4	1:445
A_2	·80	·10	0	·10	·267	1·286	1·43	1:48
A_3	·80	·10	0	·10	·233	1·243	1·46	1:535
A_4	·80	·10	0	·10	·20	1·2	1·5	1:6
B_1	·732	·133	·033	·10	·207	1·286	1·43	1:48
B_2	·732	·133	·033	·10	·256	1·27	1·44	1:447
B_3	·732	·133	·033	·10	·244	1·257	1·45	1:515
B_4	·732	·133	·033	·10	·233	1·243	1·46	1:535
C_1	·666	·167	·067	·10	·233	1·243	1·46	1:535
C_2	·666	·167	·067	·10	·244	1·257	1·45	1:515
C_3	·666	·167	·067	·10	·256	1·27	1·44	1:447
C_4	·666	·167	·067	·10	·267	1·286	1·43	1:48
D_1	·60	·20	·10	·10	·20	1·2	1·5	1:6
D_2	·60	·20	·10	·10	·233	1·243	1·46	1:535
D_3	·60	·20	·10	·10	·267	1·286	1·43	1·48
D_4	·60	·20	·10	·10	·30	1·33	1·46	1:445

Plate 2

Series B

Cone 03

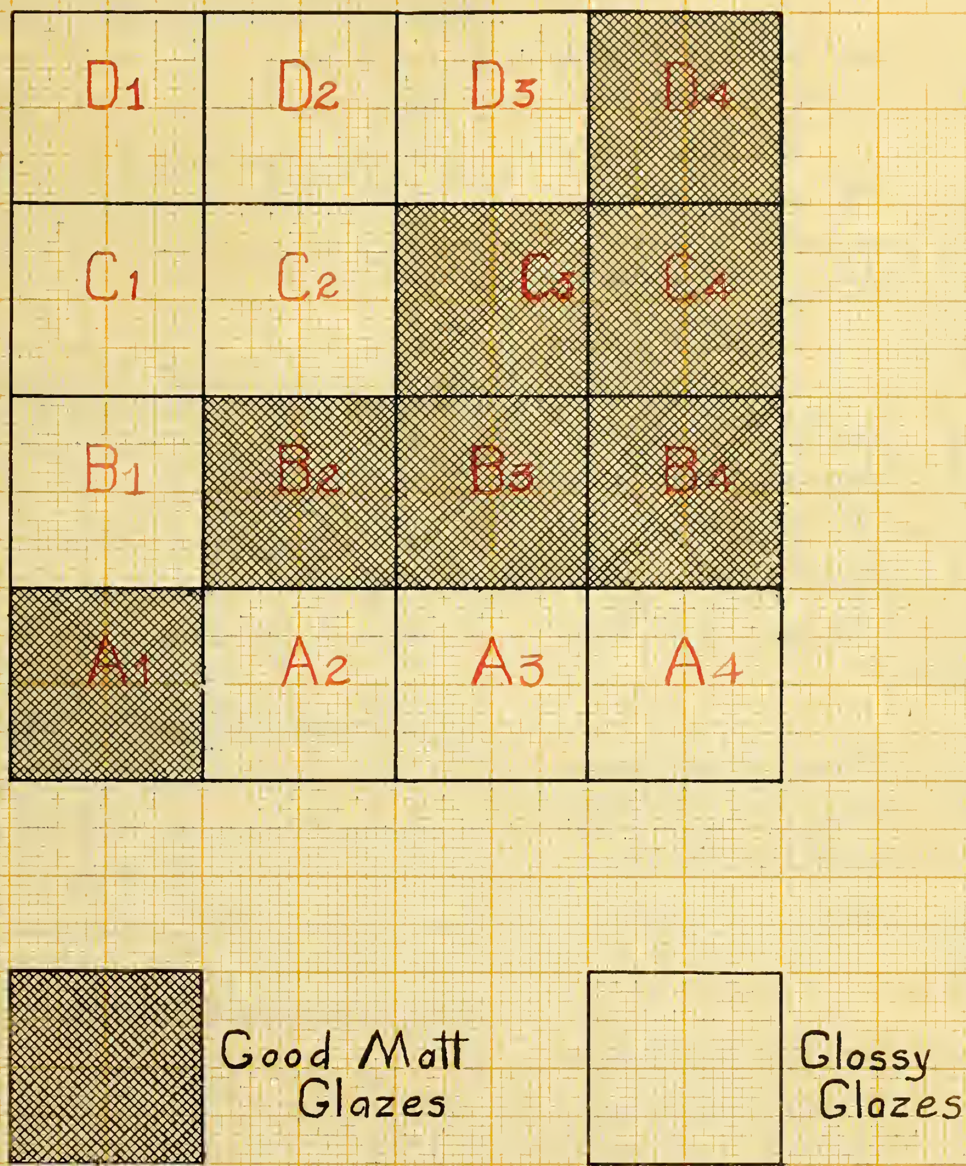

Table 2a Series B Cone 03

Batch Weight Calculations of the Four Corner Glazes

A1	·8PbO	·10K_2O	·10CuO	·0ZnO	·3Al_2O_3	1·33SiO_2
	·80					
		.10			·10	·60
			·10			
					·20	40
						·33

·80 Red Lead =·8X228 = 183
·10 K·Spar =·10X556 = 55·6
·00 ZnO = 0
·10 CuO =·10X80 = 8
·2 Tenn B·C =·2X258 = 51·6
·33 SiO_2 =·33X60 = 19·8
318·0

A4	8PbO	·10K_2O	·10CuO	0ZnO	·2Al_2O_3	1·2SiO_2
	·80					
		·10			·10	·6
			·10			
					·1·0	·4
						·2

·8 Red Lead =·8X228 - 183
·10 K_2 Spar =·10X556 = 55·6
·10 CuO =·10X80 = 8·
·1 Tenn·B·C =·1X258 = 25·8
·2 Flint =·2X60 = 12
283·4

D1	·6PbO	·20K_2O	·10CuO	·10ZnO	·2Al_2O_3	1·2SiO_2
	·60					
		·20			·20	1·2
			·10			
				10		

·6 Red Lead =·6X228 = 136·8
·20 K·Spar =·20X556 = 111·2
·10 CuO =·10X80 = 8
·10 ZnO =·10X80 = 8
264·0

D4	·6PbO	·20K_2O	·10CuO	·10ZnO	·3Al_2O_3	1·33SiO_2
	·60					
		·20			·20	1·2
			·10			
				·10	·05	·1
					·05	
						·03

·6 Red Lead =·6X228 = 136·8
·20 K·Spar =·20X556 = 111·2
·10 CuO =·10X80 = 8
·10 ZnO =·10X81 = 8·1
·05 Tenn·B·C =·05X258 = 12·9
·05 $Al_2O_3 \cdot 3H_2O$ =·05X156 = 7·8
·03 Flint =·03X60 = 1·8
286·6

Table 3 Series C Cone 03

Matt Glazes

	PbO	K_2O	CaO	CuO	Al_2O_3	SiO_2	O.R.	Ratio
A1	·5	·15	·25	·10	·20	1·0	1·25	1:5
A2	·5	·15	·25	·10	·20	1·25	1·56	1:6·25
A3	·5	·15	·25	·10	·20	1·5	1·88	1:7·5
A4	·5	·15	·25	·10	·20	1·75	2·14	1:8·75
A5	·5	·15	·25	·10	·20	2·0	2·5	1:10
B1	·5	·15	·25	·10	·25	1·0	1·14	1:4
B2	·5	·15	·25	·10	·25	1·25	1·43	1:5
B3	·5	·15	·25	·10	·25	1·5	1·71	1:6
B4	·5	·15	·25	·10	·25	1·75	2·0	1:7
B5	·5	·15	·25	·10	·25	2·0	2·24	1:8
C1	·5	·15	·25	·10	·30	1·0	1·05	1:3·3
C2	·5	·15	·25	·10	·30	1·25	1·31	1:417
C3	·5	·15	·25	·10	·30	1·5	1·58	1:50
C4	·5	·15	·25	·10	·30	1·75	1·84	1:582
C5	·5	·15	·25	·10	·30	2·0	2·10	1:6·67
D1	·5	·15	·25	·10	·35	1·0	·975	1:2·86
D2	·5	·15	·25	·10	·35	1·25	1·22	1:3·57
D3	·5	·15	·25	·10	·35	1·5	1·46	1:4·2
D4	·5	·15	·25	·10	·35	1·75	1·705	1:5
D5	·5	·15	·25	·10	·35	2·0	1·95	1:57
E1	·5	·15	·25	·10	·40	1·0	91	1:2·5
E2	·5	·15	·25	·10	·40	1·25	1·13	1:3·12
E3	·5	·15	·25	·10	·40	1·5	1·36	1:3·75
E4	·5	·15	·25	·10	·40	1·75	1·59	1:4·37
E5	·5	·15	·25	·10	·40	2·0	1·81	1:5

Plate 3

Series C

Cone 03

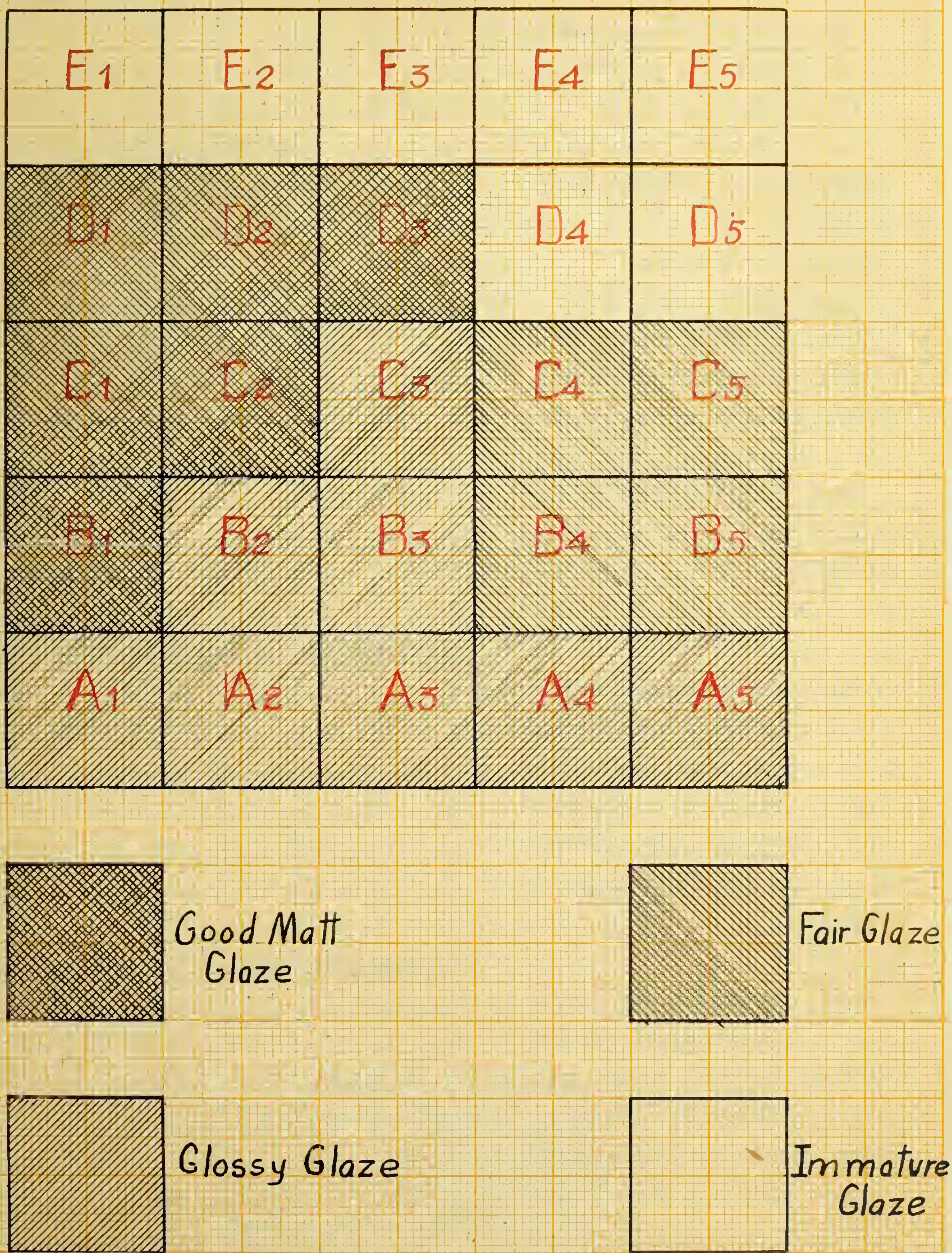

Table 3a Series **C** Cone 03

Batch Weight Calculations of the Four Corner Glazes

A1	.5 PbO	.25 CaO	.15 K_2O	.10 CuO	.20 Al_2O_3	1.0 SiO_2
	5					
		.25				
			.15		.15	.90
				.10		
					.05	.10

.5 Red Lead = .5 x 228 = 114
.25 Whiting = .25 x 100 = 25
.15 K Spar = .15 x 556 = 83.5
.10 CuO = .10 x 80 = 8
.05 Tenn B.C. = .05 x 258 = 12.9
242.4

A5	.5 PbO	.25 CaO	.15 K_2O	.10 CuO	.4 Al_2O_3	2.0 SiO_2
	.5					
		.25				
			.15		.15	.9
				.10		
					.05	.1
						1.0

.5 Red Lead = .5 x 228 = 114
.25 Whiting = .25 x 100 = 25
.15 K Spar = .15 x 556 = 83.5
.10 CuO = .10 x 80 = 8
.05 Tenn B.C = .05 x 258 = 12.9
1.0 Flint = 1.0 x 60 = 60
394.4

E1	.5 PbO	.25 CaO	.15 K_2O	.10 CuO	.4 Al_2O_3	1.0 SiO_2
	.5					
		.25				
			.15		.15	.90
				.10		
					.05	.10
					.2	

.5 Red Lead = .5 x 228 = 114
.25 Whiting = .25 x 100 = 25
.15 K Spar = .15 x 556 = 83.5
.10 CuO = .10 x 80 = 8
.05 Tenn. B.C = .05 x 258 = 12.9
.2 $Al_2O_3 \cdot 3H_2O$ = .2 x 156 = 31.2
274.6

E5	.5 PbO	.25 CaO	.15 K_2O	.10 CuO	.4 Al_2O_3	2.0 SiO_2
	.5					
		.25				
			.15		.15	.90
				.10		
					.25	.50
						.60

.5 Red Lead = .5 x 228 = 114
.25 Whiting = .25 x 100 = 25
.15 K Spar = .15 x 556 = 83.5
.10 CuO = .10 x 80 = 8
.25 Tenn. B.C. = .25 x 258 = 64.5
.60 Flint = .6 x 60 = 36
331.0